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DIODE

The present invention relates to a diode, in particular a high-power press-fit diode for a rectifier in a motor vehicle.

Background Information

Diodes are customarily used to rectify alternating currents; this is also true for rectifiers in motor vehicles, in which a rectifier bridge having a total of six power diodes is used to rectify the output currents supplied by a three-phase alternator. These power diodes are, for example, press-fit diodes, these being diodes which are pressed into a mount and thereby connected thereto.

Press-fit diodes for motor vehicle rectifiers are described, for example, in Unexamined Patent Application DE 43 41 269 and in DE 195 49 202. These publications describe the basic design features of plastic-sheathed press-fit diodes. These press-fit diodes include a chip which is connected to a head wire and a base via solder layers. The head wire and base are surrounded by a plastic sheathing which establishes a mechanical connection. The base includes a press-fitting area which deforms slightly when the diode is pressed into the rectifier.

Figure 1 shows an example of a plastic-sheathed diode known from DE 195 49 202. The diode includes mainly a base 1, a sheath 2 and a chip 3 which is situated between base 1 and head wire 4. Chip 3 is permanently connected to both base 1 and head wire 4 via solder 5a, 5b. Parts of the diode may be coated with lacquer 6. A plastic sheathing 7 provides a mechanical grip and thus also establishes a permanent mechanical connection between base 1 and head wire 4.

The basic structure of a diode described above, for example a power diode which is pressed into a rectifier for a three-phase alternator in a motor vehicle, differs only slightly from other known diodes, in particular press-fit diodes. However, the known diodes having this structure require a mounting height of at least 8 mm. The embodiment according to the present invention and described below permits a flatter design and enables the diode to be used in generator constructions in which there is not enough space for mounting heights of more than 8 mm.

However, other flat power diodes are known which have a mounting height of only 4 mm. These flat diodes include a housing having a cup-like shape which permits the reduced mounting height. When such known cup-type diodes are pressed into the rectifier sheet, the edge of the housing is inevitably deformed toward the inside, due to the press fitting between the diode and press-fit block, and presses upon the plastic sheathing protecting the chip.

To absorb or cushion this deformation, the plastic sheathing in such a known cup-type diode is made of a rubber-like soft casting compound, for example filled silicone. This results in the disadvantage that any tensile loads which may be present act directly upon the solder connecting the chip to the base and head wire, or upon the chip itself. To solve this problem, a strain relief may be provided in the head wire, which makes handling difficult during processing and requires additional operations. In addition, the elastic sheathing does not provide secure clamping of the diode base and head wire without additional measures, so that the solder and chip are not relieved by the sheathing in the event of temperature changes. Under some circumstances, this may result in a shorter diode life.

Advantages of the Invention

The diode according to the present invention, having the features of the main claim, has the advantage that only a minimal mounting height is required, the diode may be especially easily pressed into the rectifier, and a longer service life in the event of temperature changes, as well as a higher mechanical sturdiness, are ensured. These advantages are achieved by designing the diode in such a way that, in addition to known components, at least one gap is provided which enables deformation to take place during press-fitting and reduces or avoids resulting mechanical forces. The fact that the diode is press-fittable on both sides and includes a hard casting compound is particularly advantageous.

Further advantages of the present invention are achieved by the measures specified in the subordinate claims. It is advantageous that the diode, in particular the press-fit diode, includes a chip which is connected via solder layers to a first part (head wire) and to a second part (base), and is surrounded by a plastic sheathing which is provided at least in the chip region and forms a mechanical connection. The second part, i.e., the base, forms a part of a housing which at least partially encloses the plastic sheathing, at least one undercut being provided for fixation. The housing or base is advantageously made of an electrically and/or thermally conductive material. The height of the base is advantageously selected to achieve adequate clamping of the base and head wire, and it is advantageously at least 0.5 mm to 0.8 mm.

The housing may have bevels or lead-in chamfers in the press-fitting area which enable the diodes to be pressed into a rectifier on both sides. In an advantageous embodiment, the plastic sheathing between the housing and the chip is made of at least one sleeve and a sub-area filled with a casting

compound. The housing forms a cup edge having a first inner diameter and an area having a reduced inner diameter.

The gap may be advantageously adjusted to the requirements; this applies equally to its width, depth and shape, an advantageous embodiment being a gap having an approximately uniform width and another advantageous embodiment having a v-shaped gap whose width decreases in the direction of the bottom of the base.

Drawing

Exemplary embodiments of the present invention are illustrated in the drawing and explained in greater detail in the following description. Specifically, Figure 1 shows a known diode; Figure 2 shows an overall view of a diode according to the present invention, and Figure 3 shows details of the diode base (M base). Figure 4 shows a schematic representation of a rectifier having holes for the diodes to be press-fit. Figures 5 and 6a through 6c show further embodiments of the design of diodes according to the present invention. Figure 7 shows structural details of the base in a further exemplary embodiment; and Figures 8a through 8f show additional structural embodiments of diodes according to the present invention.

Detailed Description of the Embodiments

In the case of diodes according to the present invention, the principle structure of a known diode illustrated in Figure 1 is modified or optimized. Figure 2 shows an exemplary embodiment of a preferably plastic-sheathed diode according to the present invention. The diode also includes a base 1, a sleeve 2 and a chip 3 which is situated between base 1 and head wire 4. In the area of chip 3, base 1 has an in particular rotationally symmetrical pedestal 8 which rises

above a trench 9 by a height a. Edge 10 is situated on the outer area of base 1 in a rotationally symmetrical manner. Chip 3 is permanently bonded to both base 1 and head wire 4 via solder 5a, 5b. Parts of the diode, for example the outside of chip 3, may be coated with lacquer 6, the lacquer coating constituting an optional feature. A plastic sheathing 7 provides a mechanical grip and thus also establishes a permanent mechanical bond between base 1 and head wire 4.

In the exemplary embodiment of a diode according to the present invention illustrated in Figure 2, at least one or more of the components base 1, sleeve 2, chip 3, head wire 4, solder 5, lacquer 6 and/or plastic sheathing 7 are modified or specified compared to the known embodiment illustrated in Figure 1, so that the advantages specified according to the present invention are obtained. Base 1, sleeve 2 and plastic sheathing 7 form a housing, known as the M housing.

For reasons of good electrical conductivity and, at the same time, good thermal conductivity, base 1 is made of high-purity copper. An undercut B is also provided during the manufacture of the base to ensure secure fixation. Undercut B is provided in the area of pedestal 8 and may be designed, for example, as a circumferential collar. The dimensioning must be selected so that the dimension of height a is large enough to provide sufficient space for base 1 and head wire 4 to be clamped by plastic sheathing 7. In the exemplary embodiment, this space is 0.8 mm; however, at least 0.5 mm is required. A smaller dimension may, under some circumstances, result in a shorter service life in the case of thermal shock stress.

In the upper base area, the inner diameter of the "cup edge" or pedestal 8 increases due to undercut B, thereby, in the assembled state, creating a clearance between mounted sleeve 2 and the edge of the base. The upper and lower edges have

bevels or lead-in chamfers C and D which facilitate insertion during assembly. To ensure solderability, a nickel layer is applied without current to the copper surface of base 1.

Sleeve 2 is designed, for example, in the shape of a cylinder and is made of polyester, for example PET or PBT, and serves as a mold for the plastic sheathing, which is made, for example, of quartz-filled epoxy. Sleeve 2 seals the lower diode area and has essentially the same structure as known diodes according to Figure 1. The sleeve is press-fitted during the manufacture of the diode, after the base and diode head have been assembled and soldered. Cylindrical sleeve 2 in this exemplary embodiment has a slightly larger outer diameter than the cup area of base 1.

Chip 3 is a semiconductor chip which, depending on the electrical requirements, has at least one pn junction and thus performs a diode function. However, a Zener diode function, a transistor function or another function known in semiconductor technology may also be implemented.

Head wire 4 has the same shape and function as the head wire of an known press-fit diode, for example the press-fit diode known from DE 195 49 202 according to Figure 1. The size, in particular the diameter, is adjusted to the chip size or chip supporting surface of the base. The diameter of the head wire plate must be smaller than the diameter of the chip support of the base. The material and surface are identical to the material of base 1, which means the material is, in particular, copper which has been further plated, if necessary, with nickel.

A solder which is customarily used in the manufacture of press-fit diodes or power diodes for vehicle rectifiers is used as solder 5a, 5b.

Lacquer 6, which is applied to the outer area of the chip, but is not absolutely necessary, has a composition that is customary in semiconductor technology.

Plastic sheathing 7 is implemented as a hard casting and made from a quartz-filled epoxy.

In contrast to the known cup-type diodes in which hard casting is not possible, a hard casting of this type may be provided for the diode according to Figure 2. In the case of cup-type diodes, cracks which produce leakage in the sheathing occur when the diode is pressed into the rectifier, due to the edge deformation and resulting force upon the casting compound. A crack formation of this type is avoided by inserting a plastic sleeve 2 as the mold for the hard casting compound. The clearance or gap A having depth t and width b, which occurs between plastic sleeve 2 and pedestal 8 of base 1, prevents a harmful force from being produced on the hard casting compound as a result of the deformation of the copper edge during press-fitting. For this purpose, gap A must be at least as wide as the difference between diameter D1 of the press-fit hole in rectifier 11 and diameter D2 of the diode. For example, width b of the gap is approximately 0.1 mm. Gap A causes base 1 to form an edge 10 having a first inner diameter and an area having a reduced inner diameter.

Bevels or lead-in chamfers C and D are provided on the top and bottom for the purpose of press-fitting the diode on both sides. The diode is thus pressable into rectifier 11 either from below or from above, using an annular die which is not illustrated. During press-fitting from above, annular surface E serves as the contact surface for the press-fitting die.

Figure 3 shows a schematic representation of rectifier 11; it includes six press-fit holes 12, each having a diameter of D1, into which the diodes are to be pressed. Following suitable

electrical interconnection, the six diodes then form the rectifier.

Figures 4a through 4d show further details of the design of the diode base in the exemplary embodiment according to Figure 2. Figure 4a shows the entire base with reference to details X, Y and knurling R, which serves to improve the press-fitting performance. Detail X shows one of the bevels (Figure 4c) and detail Y the area containing the slot.

Figures 5 and 6 show additional exemplary embodiments of diodes according to the present invention. The individual components are identified by the same reference numerals as the exemplary embodiment according to Figure 2.

In an embodiment illustrated on the right side of Figure 5, the sleeve is clamped on its inner diameter, and the entire outer surface of the sleeve is kept contact-free. For this purpose, trench A' is made sufficiently deep to prevent contact between sleeve 2 and outer or edge area 10 of base 1. This prevents the transmission of force during press-fitting. The sleeve may also be glued and, if necessary, have an additional groove.

The exemplary embodiment according to Figures 6a through 6c also includes a notch F which is advantageous for the manufacture of the diodes and establishes, for example, a secure attachment during manufacture. In other respects, these exemplary embodiments differ only in terms of their design details, in particular their dimensioning, which are illustrated in detail in the drawing.

Figure 7 shows another option for dimensioning a diode base.

Figures 8a through 8f show six additional embodiments of the present invention. In each case, gap A is provided with a v-

shaped design, i.e., having a decreasing width b in the direction of the diode base.

Diode head or head wire 5 may be smooth or stepped, designed for example to have 2 to 6 steps. The angle of the head wire bevel is, for example, 20° or 50° or a value therebetween or a higher or lower value, it being possible to adjust this value to the requirements.

Depending on the embodiment, trench 9 has a smooth surface or is structured and includes, for example, a notch-shaped indentation. An elevation 9a of variable design is provided for attaching sleeve 2. In these exemplary embodiments, sheath 2 may be secured during diode manufacture by selecting the inner diameter of sleeve 2 so that it is smaller than the outer diameter of elevation 9a. This fixes cylindrical sleeve 2 when it is press-fitted or mounted.

Trench A having a uniform diameter b or a v-shaped design in the embodiment is obtained by shaping inner edge area 10 of base 1 accordingly during the manufacture of the diode. Since the trench permits certain deformations, the problem of crack formation during press-fitting does not occur even in the case of a hard-cast diode. Furthermore, diodes of this type may be pressed into a rectifier from both sides.

The dimensions specified in the figures and description are suitable dimensions which may be varied within certain ranges. In particular, the maximum and minimum values indicate limits for possible value ranges. The ratios between certain variables, for example the ratio between trench depth t or pedestal height a and height h1 or h2 should lie within certain value ranges which are defined by the values or value ranges indicated in the figures.